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(54) **Machine for breaking bulk material**

(57) The present invention concerns a machine for breaking up bulk material by means of a cutting mechanism which comprises at least two shafts driven contradirectionally and equipped with cutting tools, and is supplied with the material which is to be broken up via a chute or hopper leading to the working area of the cutting tools, the drive to the cutting mechanism being switchable into reverse drive in case of overload, as a function of a preset nominal drive value, and back again into forward drive, characterised in that the feed chute or the like may be closed off by a shutter element. The operation of the machine is controlled by a control circuit which takes into account, in controlling the cutter drive and the shutter, the motor temperature and r.p.m.

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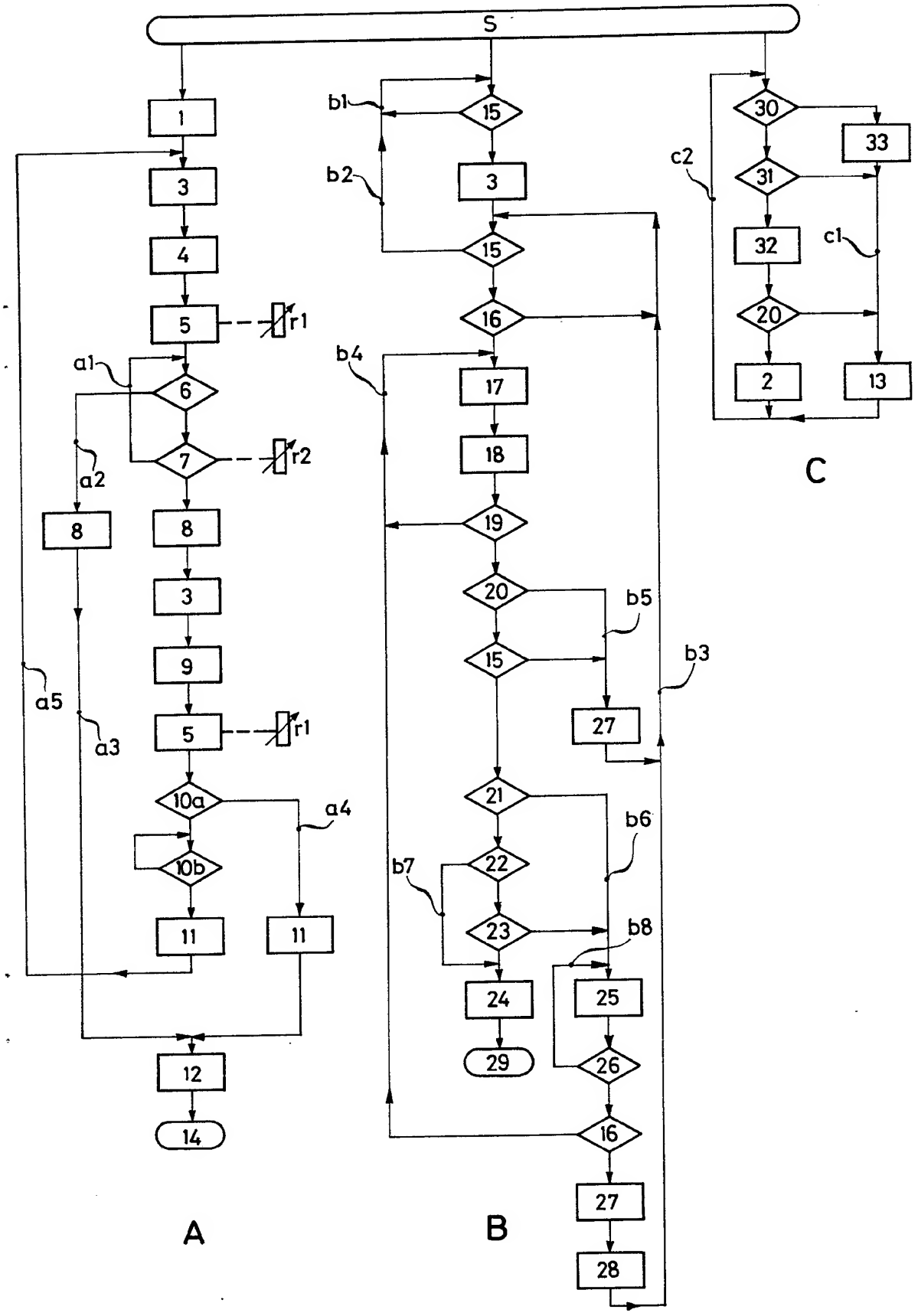
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SPECIFICATION

Improvements in or relating to machines for breaking bulk material

The present invention concerns machines for breaking up bulk material. An object of the invention is to devise a comminuting machine having a cutter motor driving cutters fed with material to be comminuted via a chute and which operates largely free of incident and which has associated control and monitoring circuits which prevent damage to the cutter motor due to overload or of failure of a grid phase.

Accordingly the present invention consists in a machine for breaking up bulk material by means of a cutting mechanism which comprises at least two shafts driven contra-directionally and equipped with cutting tools, and is supplied with the material which is to be broken up via a chute or hopper leading to the working area of the cutting tools, the drive to the cutting mechanism being switchable into reverse drive in case of overload, as a function of a preset nominal drive value, and back again into forward drive, characterised in that the feed chute or the like may be closed off by a shutter element.

The initially defined inventive machine is so constructed in order to resolve this problem that the feed chute may be closed off by means of a shutter element. In the case of a machine which is equipped with an oscillator element operating in the area of the feed chute for follow-on feed of material lying loose within the feed chute, the oscillator element appropriately acts as a shutter element. The oscillator element can thus act as a feed and as a shutter by being appropriately driven or moved.

The possibility of being able to shut off or choke off the feed chute, that is directly above the working area of the cutter tools, offers the special advantage that continued dropping of material which is to be comminuted may be averted by shutting off the feed chute in case of already occurred clogging of the cutting tools or excessive thermal load on the cutter motor, in order thereby to give the machine the opportunity of working itself clear, for example by reverse operation, without intervention by an operator.

To prevent the cutter motor being damaged in case of critical single-phase operation, particular periods and minimum r.p.m. figures are preset for running this motor up to speed in reverse operation as well as forward operation. The motor is switched off immediately, if the cutter motor has not reached the particular minimum r.p.m. within the preset period in question.

The possibility exists moreover of working with a control system making allowance for the coil temperature of the cutter motor and of causing the same to control the drive of the shutter element or rather oscillator element, in such manner that the shutter element is stopped in its momentary position upon reaching a preset emergency coil temperature and is thereupon directed into the closed position.

In order that the present invention may be more readily understood an embodiment thereof will now be described by way of example and with reference to the accompanying drawing which is a block diagram of a control system for a comminuting machine, which control system is constructed in accordance with the present invention.

Referring now to the drawing the Part A is at the left in the drawing and relates to a cutter motor control system, the central Part B relates to the control system for an oscillator element acting as a shutting slider, and the right-hand Part C relates to a control system for monitoring the cutter motor in respect of its operating temperature and triggering controlling and indicating actions if an emergency temperature is reached. All three control systems A, B and C may simultaneously be placed in operation or placed in readiness by depressing the start key S.

If particular controlling, governing, measuring and indicating blocks occur several times in one of the control systems or appertain to several of the three control systems and concomitantly also have to perform identical tasks and functions, these blocks, for the purpose of simplification, will bear identical references. Before giving a particular description of the structure and operation of the control systems, a list of the different circuit blocks incorporating the corresponding reference symbols and brief indications of their task and function will first be given in the following list:—

S start by switching on the machine
1 "blocking" OFF lamp
2 OFF flasher
3 pause
4 cutter tool — reverse ON
5 cutter tool drive — running-up period
6 minimum r.p.m. reached or exceeded?
7 preselected period for reverse operation terminated?
8 cutter tool — reverse OFF
9 cutter tool — forward ON
10a preselected minimum r.p.m. reached or exceeded?
10b preselected minimum r.p.m. maintained or still exceeded?
11 cutter tool — forward OFF
12 "blocking" ON lamp
13 ON flasher
14 "program completed by blocking" lamp
15 cutter tool — forward ON?
16 oscillator element manual selector ON?
17 oscillator element inward thrust displacement
18 hydraulic array ON
19 oscillator element "thrust displacement" — switchover pressure reached?
20 cutter motor — emergency temperature reached?
21 time program switched on?
22 material present in chute?
23 program work period elapsed
24 plant OFF

25 oscillator element — outward displacement
26 oscillator element — terminal position "outward displacement"?
27 oscillator element STOP
28 hydraulic array OFF
29 program termination after automatic switch off
30 cutter motor — limiting temperature exceeded?
31 blocking present?
32 cutter drive freed
33 block cutter drive

The control circuit A for the cutter motor will now be described with reference to the corresponding explanations regarding functions of the control blocks 1 to 33. After depressing the start key S, the cutter should always start first in reverse to loosen any material for comminution which may have become jammed in the cutter mechanism at the end of the preceding comminuting operation. Moreover, the initial reverse operation, among other actions, should always occur with the oscillator element inserted, thereby always assuring loadless running-up of the driving motor so that the running-up period itself may be used as a parameter determining control actions.

The "blocking" indicator lamp 1 will not light up at the start of a program in normal cases, unless an as yet uncancelled blocking state was present at the end of the preceding program. The timing element 3 switches on a pause or interval prior to initiation of operation in reverse, which in principle is of importance only in the case in which the cutter motor is switched over from forward into reverse thereby preparing a period enabling the revolving masses to run down to a standstill in the direction of forward rotation.

After this time or interval has elapsed, the motor relay 4 operates for reverse operation of the cutter motor, so that the latter starts in reverse. The timing element 5 presets a period — via the setting element r1 — for running-up of the masses in reverse up to a predetermined minimum r.p.m. After expiry of this preselected period, the signal travels onwards to block 6. The momentary motor r.p.m. is measured or counted by means of a tachometer associated with control block 6. In doing so, a constant scan is operated to determine whether the minimum r.p.m. has been reached or is still operative during operation in reverse. If so, the control block 6 generates an output signal YES which reaches the timing element 7 with which the total period for operation in reverse is preset via the setting element r2. This timing element 7 feeds an output signal NO via the line a1 to the input terminal of the control block 6 until the preset time for operation in reverse has expired, so that the cutter mechanism has the opportunity in any event of clearing material inclusions which has not as yet led to a jamming condition.

If, however, the period preset for reverse has elapsed and the drive has failed to reach the minimum r.p.m. this can only imply a high mechanical overload or even seizing up or possibly even fracture of the driving belt or of other driving elements, in which case the control block 6 generates an output signal NO or rather "minimum r.p.m. not reached during preset period in reverse" and feeds the same via line 2a to the motor relay 8 which then releases and immediately deactivates the cutter motor. Following this, the "blocking" flasher 12 and the "program interruption by blocking" lap 14 are energised via line a3, so that the operative is apprised by visual means that a blocking action in reverse has occurred, which should be eliminated after determining its cause. An automatic switchover of the motor into forward operation does not occur in this kind of trouble, since it must be expected that in forward operation the motor will also fail to reach the required minimum r.p.m.

The monitoring of the motor r.p.m. during operation in reverse by means of the control blocks 5 and 6 provides, apart from switching off in case of an emergency, an extremely reliable early deactivation of single-phase operation which is dangerous to the motor, without having to keep a special watch on the mains supply. The same logic also applies in respect of the subsequently described r.p.m. monitoring action during operation of the motor in the forward direction.

If the minimum r.p.m. in reverse is reached within the fixed running-up period and the time preset for operation in reverse has elapsed, a YES signal is generated at the output terminal of the control section 7 for "end of reverse period"; the lower relay 8 releases, and the cutter motor is isolated from the grid. An interval for run-down of the machine from reverse running to safe standstill is preset by means of the next timing element 3, whereupon the power relay 9 is energised for forward running. The motor then consequently runs forward, i.e. in the working direction of the cutter mechanism.

The setting element r1 is utilised to preset a period on the next timing element 5, during which the motor should be run up to a fixed minimum r.p.m. whilst running forward. After expiry of the preset period, the signal is led to the tachometer system 10a. If the motor has not reached the minimum r.p.m. during the present running-up period, the control circuit 10a generates an output signal NO fed to cutoff 11 via line a4, which stops the motor immediately. This is also indicated in the manner described hereinbefore by means of the two indicators 12 and 14. This indication will normally mean that the cutter mechanism had failed to work itself clear during the preceding run in reverse or that material has jammed in the cutter mechanism whilst running forward.

If, on the contrary, the cutter motor has reached the minimum r.p.m. within the preset running-up period, the control circuit 10a generates an output signal YES fed to the input terminal of another control circuit 10b which thereupon takes over the monitoring of the driving r.p.m. in normal forward operation, by performing a scan, e.g. at a

frequency of 5 hz, to determine whether at least the preset minimum r.p.m. is still being maintained. Only if this is not the case, and output signal NO is generated which de-energises the power relay 9 for forward running to stop the motor from running forward. A signal then travels via line a5 to the initially described switching circuit for operation of the motor in reverse, that is to say to the input terminal of the time function element 3. In this case, the cutting tool then performs a reversing operation, the motor being initially switched to reverse after the interval set by the time function element 3 in manner already described, and thereupon being switched back to forward running, in the expectation that the cutting mechanism had worked itself free in the meantime and that the motor may finally reach the required minimum r.p.m. in forward operation within the preset running-up period. In principle, this reversing action may be repeated automatically with optional frequency if the operative does not deactivate the drive or rather the control system.

The control circuits 10a and 10b for monitoring the speeds of revolution during forward operation fulfil the task of a reliable early switchoff in case of possible single-phase operation, without having to make use of the systems for monitoring the symmetry of the three-phase grid which are otherwise required for this purpose and which are very costly. If a grid phase fails during normal operation, that is during forward running of the cutter motor, the torque/r.p.m. characteristic of the motor acquires a greatly altered outline. As a matter of fact the pull-out or breakdown torque diminishes considerably, and the starting torque even drops to nil. This means however, that the continuously monitored minimum r.p.m. is no longer maintained and that the machine is consequently switched to reverse. Since the torque is then nil at nil r.p.m. the motor can no longer start, thereby immediately triggering switchoff from the grid. Merely the inactive interval period preset by the time function element 3 and the running-up period preset by the time function element 5 thus elapse until early deactivation intervenes. This period, established by time function element 5, and lasting approximately 5 s is comparatively short so that the motor cannot incur any damage under single-phase running.

The control system B for the oscillatory element used as a shutter slide which operates within the feed chute in front of the intake region of the cutting tools, is so arranged that the oscillator element operates only during normal forward running of the cutter mechanism, but shut off the feed chute during reverse operation, that is to say being scheduled to be inserted. After the start key S is depressed, the control element 15 is consequently used first to query whether operation in forward direction is switched on for the cutter mechanism. When the cutter motor is stopped or runs in reverse, the control element 15 will feed an output signal NO to its input terminal via the line b1 and will not cause operation of the oscillator element drive — for example operating with a hydraulic assembly — for opening the oscillator element. To facilitate running-up in forward direction of the cutter motor and thereby to establish unequivocal conditions for adjustment of the running-up period, and to prevent said running-up from being impeded immediately by material continuing to drop from the feed chute, an interval of approximately 10 s is initially activated by means of the time function element 3, and confirmation that forward running is still being maintained even after this interval for the cutter mechanism is assured by means of the next control element 15. If NO, this is reported back to the input terminal via the lines b2 and b1, to repeat the action described. If YES, that is if the cutter mechanism is actually still in forward operation, the control element 16 is utilised to query whether the complementary manual selector switch for the oscillator element is switched on, i.e. whether the oscillator element should operate at all.

If this selector switch is not switched on, the control element 16 transmits an output signal NO to the control line b3, via the control element 15 and back to the input terminal of the control element 16, so that the oscillator element does not operate. If the selector switch is energised, the control element 16 however transmits a signal YES to the control unit 17, to release the oscillator element for opening movement. The oscillator element should initially always start in its closed position shutting off the supply chute.

After authorisation of opening movement of the oscillator element, power is supplied by the ON circuit 18 to the hydraulic assembly, and the oscillator element is entrained in the direction of inward displacement until an obstacle ends this displacement, that is until the oscillator element is impeded, say by unfavourably positioned material or has finally reached a terminal stop. An increased pressure is thereby generated in the hydraulic drive system for the oscillator element drive which is monitored by the terminal position control unit 19 operating with a pressure gauge to ascertain whether the preset maximum value of the operating pressure or rather the terminal pressure for reversal of the oscillator element into the other direction of displacement has been reached. If NO, this state is reported continuously to the control unit 17 via the line b4, so that the oscillator element still continues to be thrust in its feed direction. Otherwise, that is when the preset pressure value is reached, the output signal YES of the control unit 19 is processed in the post-connected control blocks i.e. checking on whether additional material replenishment may or can be operated.

These control blocks include a control unit 20 taking account of the coil temperature of the cutter mechanism motor. Once the preset but still acceptable "warning" temperature of the motor is reached, no other material should drop into the working space of the cutting tools. This means

that the oscillator element should not be retracted from the closed position to open the feed chute. When the warning temperature is reached, the control unit 20 transmits a signal via line b5 to the STOP control unit 27, and the latter transmits a STOP signal to the control element 15 via the control line b3. As for the rest, the oscillator element is also stopped at possible intermediate positions and then displaced to the closed position by means of control elements 15, 16, 17, 18 and 19, provided that the warning temperature has been reached.

If, on the other hand, the temperature of the cutter motor lies below the preset warning temperature, the control unit 20 generates the signal NO which reaches and activates the control element 15 to operate another precautionary query as to whether the cutter motor is still being operated in the forward direction. If NO, the hydraulic assembly is placed in the depressurised state via the control elements 27, b3 and 14 as described, and the oscillator element is thereupon displaced to the shutting position by means of the control elements 16, 17, 18 and 19.

If YES, that is to say if the cutter motor runs forward, a corresponding signal travels from the control element 15 to a control circuit 21 which takes account of a program for particular prohibited hours during which the machine may not operate, say because of noise pollution or of other reasons. If this control 21 is no longer set to take account of prohibited periods, it generates a signal NO which travels via the control line b6 to a control unit 25 which starts movement of the oscillator element to open the feed chute, as will be described hereinafter in another context.

If the control circuit 21 is switched on however, which will normally be the case, an output signal YES reaches a test circuit 22 which checks on whether the feed chute still contains material for comminution. If NO, the circuit 24 is actuated immediately via the line b7 to prevent unnecessary operation, said circuit automatically stopping the plant as a whole which is shown visually by the indicator 29 as "program end".

If, on the other hand, material is still present in the feed chute, the test circuit 22 transmits an output signal YES to a verifying circuit 23 which will check on whether a prohibited period in which operation of the comminuting machine is barred has been reached. If so, the plant is stopped by the circuit 24 receiving a signal YES. If no, the control unit 25 is energised.

The latter then causes return of the oscillator element from the inserted position in an opposed working direction by appropriately reversing the hydraulic assembly. The terminal position control unit 26 then checks by means of a terminal sensor on whether the oscillator element has already reached the other possible terminal position. If NO, a report reaches the input terminal of the control unit 25 via the line b8, so that the outwardly directed tractive displacement of the oscillator element into the freeing position is continued. If, finally, the oscillator element has been displaced outwards into its terminal open position and the terminal position sensor has been actuated, the terminal position control unit 26 transmits a signal YES to the previously cited control element 16 to check on whether the manual selector for the oscillator element is still switched on. If so, a signal YES is fed via the control line b4 to the input terminal of the control unit 17 so that the oscillator is again moved towards its closed position for replenishment packing or tamping of material and that the actions described are repeated with the corresponding alternate control possibilities.

If, however, the selector switch has been switched off during operation of the oscillator element for some reason, the control element 16 generates a signal NO for the stop control unit 27, so that the latter activates the control valves of the oscillator element hydraulic assembly to establish pressure-free circulation, and the oscillator element drive is stopped by means of the OFF circuit 28.

The control system C illustrated in the right-hand part of the drawing is affected by the temperature of the driving motor for the cutter mechanism.

After depressing the start key S, the control unit 30 co-operating with a temperature sensor is addressed to ascertain whether the acceptable limit temperature of the motor is exceeded. If this is the case, a signal YES is fed via line c1 to a circuit 33 for immediate deactivation of the motor, and this is indicated by a flasher 13.

If the limiting temperature of the cutter motor has not been exceeded, the test circuit 31 is activated by a signal NO to determine whether motor blocking is possibly present, caused by its r.p.m. monitoring system. If so, the flasher 13 is then activated via the line c1 by means of the output signal YES then generated. If, on the contrary, no blocking is present, the test circuit 31 transmits a signal NO to the release circuit 32 which then authorises starting of the cutter motor.

By means of the connected control unit 20 which is also incorporated in the operation of the control system B and which takes account of the coil temperature of the cutter motor, a check is also made to establish whether the "warning" temperature is exceeded. If YES, the flasher 13 is placed in operation. Furthermore, the oscillator element does not continue to run but shuts off the infeed of material after the next packing or tamping displacement as a shutter, until the temperature drops below the warning level again. In this connection, reference is made to the control system B whereof the control unit 20 operating as a function of temperature has its operation described.

If the warning temperature is not exceeded, the control unit 20 generates an output signal NO which, via the indicator circuit 2, either leaves the flasher 13 switched off or switches the same off again if a signal transmission had occurred previously, but the temperature had dropped below the warning level in the meantime. This

operating condition is reported back via line c2 to the input terminal of the control unit 30, so that the indication and testing procedure anent the warning temperature is repeated continuously.

It should also be understood that the comminuting machine may also operate with more than two contradirectionally driven shafts equipped with tools, in which case it is normal for two adjacent shafts to be driven contradirectionally in each case. The r.p.m. monitoring action during the running-up of the cutter motor during forward running as well as during initial reverse running could also be applied in a comminuting machine which operates without shutter elements in the feed chute.

If a shutter element is applied however in the manner described, its tasks should be taken over by the oscillator element which is incorporated in most instances in any event. Instead of the oscillator element, it would also be possible to incorporate a separate shutter element, for example such as a closing shutter or flap. As for the rest, the term "feed chute" should be understood as a structure which feeds the material intended for comminution direct to the cutter tools. This may consequently and for example be formed by a funnel-like shaft as part of the machine or of a building.

CLAIMS

1. A machine for breaking up bulk material by means of a cutting mechanism which comprises at least two shafts driven contradirectionally and equipped with cutting tools, and is supplied with the material which is to be broken up via a chute or hopper leading to the working area of the cutting tools, the drive to the cutting mechanism being switchable into reverse drive in case of overload, as a function of a preset nominal drive value, and back again into forward drive, characterised in that the feed chute or the like may be closed off by a shutter element.

2. A machine according to claim 1, comprising an oscillating element operating in the area of the feed chute or stack, intended to push onwards any material lying loose within the feed chute in the direction towards the cutting mechanism, characterised in that the oscillating element acts as a shutter element.

3. A machine according to claim 1 or 2, wherein the cutting mechanism motor is first switched into reverse drive at the start of each program and a fixed period is preset for drive in reverse, characterised in that a minimum r.p.m. is preset for the cutting mechanism motor running in reverse, that the prevailing r.p.m. of the cutting mechanism drive is monitored and that the cutting mechanism drive is switched out of reverse drive if it has not reached the minimum r.p.m. within a preset period.

4. A machine according to one of the claims 1 to 3, characterised in that a run-up period and a minimum r.p.m. are preset for operation in forward drive, that the r.p.m. of the drive running up in forward direction is monitored, and that the cutting mechanism drive is switched off if the drive has not reached the minimum r.p.m. within the preset period.

5. A machine according to one of claims 1 to 4, characterised in that the shutter element or rather the slider is moved into the shutting position during operation in reverse of the cutting mechanism drive.

6. A machine according to one of claims 1 to 5, characterised in that the oscillator element drive is controlled in such manner that at the start of a cutting program, the oscillator element initially performs an inward thrust displacement.

7. A machine according to one of claims 1 to 6, comprising a hydraulic drive for the oscillator element, characterised in that the operating pressure prevailing in the hydraulic system is monitored by means of a terminal position control system which authorises a supplementary inward thrust displacement of the oscillator element when a preset maximum value of the operating pressure has not as yet been reached, and terminates the said thrust displacement as well as authorises an outward traction displacement of the oscillator element when the said maximum pressure is reached.

8. A machine according to one of claims 1 to 7, characterised in that a control system is incorporated which makes allowance for the coil temperature of the cutting mechanism motor, that a motor emergency temperature is preset and that the control system controls the oscillator element drive in such manner that the oscillator element is stopped at its momentary position if the emergency temperature is reached and is then moved into the shutting position, where it remains until the motor temperature has again dropped below the emergency level.

9. A machine for breaking up bulk material substantially as hereinbefore described with reference to the accompanying drawings.

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